Current and Future Launch Vehicles and Facilities

SESSION IIIA

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Using the Space Shuttle *Columbia* Begin Bringing the Moon to America

Flying a Re-Engineered OV-102 Columbia *at Marginal Cost to Repeatedly Launch Small, Low Cost Commercially-Operated Devices to the Moon - A Method of Generating Data, Revenue & Public Interest*

How *Columbia* Can Help Bring the Moon to Americans

Flying a Re-Engineered OV-102 Columbia *at Marginal Cost to Repeatedly Launch Small, Low-Cost, Devices to the Moon -*

A Method of Generating Data, Revenue & Public Interest

Addressing the *Why, What & How* of Leading America Beyond Earth Orbit

The purpose of this paper is to propose a realistic enterprise framework that addresses how America's space program resources can best serve its free enterprise system as it expands above and beyond Earth orbit. Before completing the discussion, three important questions will need to be addressed:

1. *Why* would America commit one of its Shuttles to launch devices beyond Earth orbit?
2. *What* could private interests accomplish if they had at their disposal a routine, profitable means of transportation to the Moon? Are there any enterprises currently envisioned that urgently need a low cost, routine, medium lift capability?
3. *How* can we best take advantage of our existing launch infrastructure and experience to serve private industry's desire to begin earning profits from ground-based enterprises that use revenue-generating devices on the Moon? *How* could we use our existing capabilities to not only serve immediate opportunities, but also use them as a means of creating a public demand for engineering far more efficient space transportation systems of the future?

Recently, there have been efforts to determine how to use a Space Shuttle to return an American to the Moon at some cost goal. This is a *good* thing to do for planning the creation of a space infrastructure on the Moon. However, given the tremendous economic potential of human interest in space -is this the *best* thing America could be doing now with one of its Space Shuttles?

> *Should we endeavor next to return an American to the Moon - or, should our next national achievement in space be to bring the Moon to all interested Americans?*

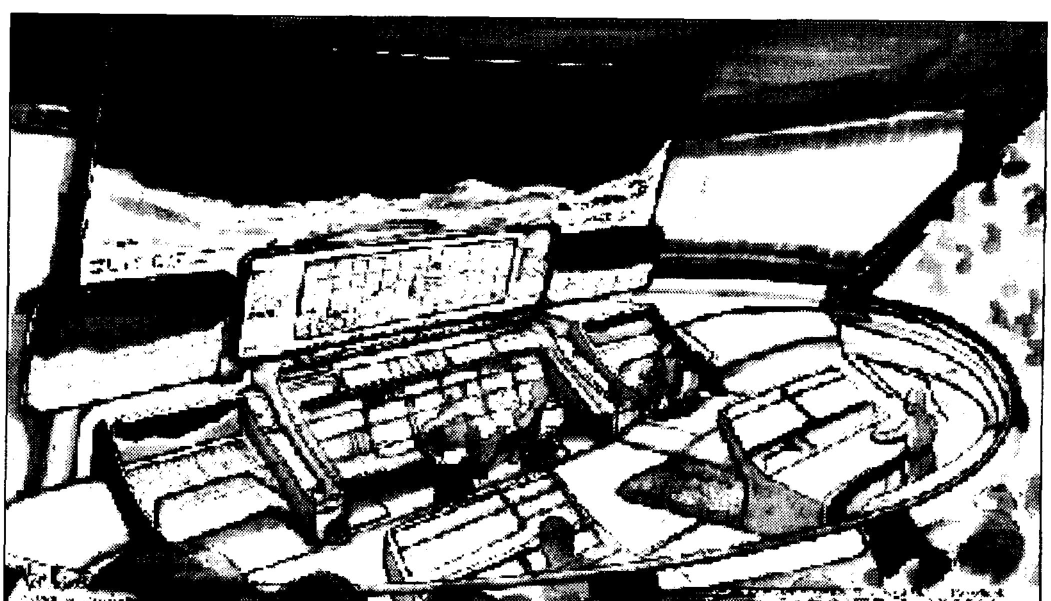
Bringing the Experience of Being on the Moon to All Interested Americans

> *No longer will we have to wait for in-space theme parks to open up for us to experience being in space - the 21st century American dream of exploring and interacting with the space frontier may well be affordable and achievable for us to begin now through the development of ground-based space theme Parks.*
>
> *We do not necessarily have to wait for a Shuttle replacement - although, if the enterprise truly takes off, there will be a market demand for a replacement.*

A very interesting aspect of the upcoming Mars Pathfinder Rover mission is not just the technical achievement of operating a micro-robot on the surface of Mars. Nor is it the potential scientific data that will be collected. The most intriguing aspect of the device is its revenue-generating capability and the impact this could have on Americans interested in exploring space.

A recent *Civil Space Transportation Study* (CSTS) [1] noted that one of the most realistic, near-term markets is something they referred to as *"ground-based space theme parks."* In this vision of space enterprise, people come to visit attractions that are at once entertaining and educational. People pay to see it, they are entertained and, perhaps, they have encountered a new frontier and experience that inspires them to learn more, experience more and interact more.

Planetariums, science museums, aquariums, and Disney's EPCOT are but a few examples of similar financial ventures. Imagine allowing visitors to observe or participate in live lunar excursions with audience participation, exploration and inquiry. This would generate an increasing degree of public interest, revenue, as well as scientific and technical data.



(LunaCorp, Arlington, VA)

A ground-based space theme park *is one* example of the kinds of enterprises that could be initially sustained through the use of a designated Shuttle Orbiter

University departments may decide to jointly invest and partner with technology firms to conduct civil engineering, mining, power generation and other industrial experiments with remote devices that the y own and operate.

Once initiated, private industry (e.g., power-generating companies, mining and construction interests) may also see opportunities for earning revenue by providing basic infrastructure needs that expand upon the primitive capabilities that ignited the enterprise. Such an endeavor would represent a process of bringing the Moon to America - perhaps a required step before Americans will be willing to relinquish billions of dollars to send an American back to the Moon.

Lifting Free Enterprise to the Moon Requires a Steadily Increasing Annual Flight Rate

Taking entrepreneurial visions to the Moon will require providing the customer a sizable and steadily increasing *annual lift capability.* This will mean bringing together engineers, scientists, businessmen, and marketing experts to strike the right balance between performance, operations and economics if the proposed space transportation service is to sustain a market. Specifically, technical skills would be needed to focus space transportation system improvement not only on *how much* it can deliver from launch to deployment, but *how often* it can deliver. By truly serving the needs of free enterprise, engineers and scientists (government and industry alike) must take the time derivative, so to speak, of the rocket equation and derive systems that provide an ever increasing number of affordable pounds to orbit *per year.*

An expanding economy in space will require not only cost reductions in launch services -it will require steadily increasing revenue from the devices launched into space. This has been the case for ownership and leasing of transponder space on communications satellites, and will undoubtedly be the case for free enterprise expansion beyond Earth orbit. In order to sustain and grow these enterprises it will be necessary to maintain and service the operation of these remote devices as well as provide the capability to keep up with demand for their use. This will require space transportation systems that possess the capacity to meet the challenge of increased flight rates.

A Profound Realization - We Can Initiate Lunar Enterprises Now With One Shuttle

With the advent of small (less than 100 lb.) tele-operated devices such as NASA’s Mars Pathfinder Rover, which is to be launched this year (1996), it seems possible to contemplate today the beginnings of an enterprise that lands many such devices on the Moon. The next obvious questions are 1.) how many such devices could be landed each year, 2.) how could revenue be generated from them, 3.) what would they do, 4,) how much revenue could they generate, and 5.) what would be the annual launch expenses to continually land and maintain them? Finally, what are the prospects of increasing current launch capability over time should the enterprise take off?

In pondering such issues, a profound awakening is occurring:

> *Question: Just what type of space transportation system is required to ignite a billion dollar, sustained enterprise on the Moon?*
>
> *Answer: The Space Shuttle* Columbia. *Particularly, if it is re-engineered over time for a higher flight rate - from the current three (3) per year to, perhaps, seven (7) per year. Additionally, since it is overweight to perform meaningful transportation services for the International Space Station Alpha (ISSA) program, it is an ideal vehicle to choose for such an enterprise.*

Flying *Columbia* for Both Space Flight Development and a National Enterprise

The Space Shuttle *Columbia* can be operated cheaper than most popular expendable launch systems if its launches are provided at *marginal rates.* That is, the additional cost of operating *Columbia,* after the other vehicles' costs have been accounted for in support of the Space Station program, is about an order of magnitude lower than the *average Shuttle cost per flight* (about $500M at the currently budgeted seven flights per year)[2]. Assuming free enterprise were allowed to pay only the marginal cost of operating *Columbia* for their use, a demand could be created (at least for one reusable Orbiter) for engineering higher and higher flight rates at lower and lower costs per flight.

It should be clearly recognized, however, that the use of *Columbia* only makes sense for the start-up and initial take-off phases of the enterprise. The Shuttle system, even with the enhancement suggestions envisioned, will reach a limit that will drive the nation toward advanced space delivery systems. The use of a Shuttle for starting a lunar enterprise, therefore, is not *the answer* for space delivery, but rather our *next opportunity.*

Re-Engineering Columbia in Support of a Lunar Enterprise

Utilizing the Space Shuttle *Columbia* for a lunar enterprise is envisioned to require a two step process. First, re-engineering of the processes (both on and off-site) involved in preparing *Columbia* for re-flight in the context of a focused cargo delivery role. The second phase would re-engineer some of the vehicle systems and components themselves to allow lower levels of servicing, test time and repair. This would allow the *Columbia* work force (across the program) to achieve greater effectiveness by launching it more often (i.e., without requiring added engineering, program control, overtime, shift work, facilities and infrastructure in general).

The Space Shuttle *Columbia* can be operated today at a flight rate of three flights per year. This has been repeatedly demonstrated on Shuttle Orbiters. The highest flight rate attained by any one Orbiter in one year is five[3]. This occurred when Discovery flew four commercial missions deploying a total of twelve spacecraft (plus a fifth DOD deployment mission) from August, 1984 to August, 1985. With one exception (the STS 68/SRL-02 flight in 1994), all Shuttle Orbiter flights have required extra work to disassemble the payload accommodations from the previous mission and assembly of unique payload accommodations for the next flight. With a single mission requirement for the newly designated Orbiter, i.e., upper stage deployment in low earth orbit (LEO), there would be no need to conduct extensive aft flight deck work, nor expensive and time consuming payload bay and mid body reconfiguration.

With a focused cargo delivery role, *Columbia's* on-orbit stay time requirement (by the payload) should be drastically reduced to only hours, not days or weeks - resulting in further launch-to-launch time savings. The American people and the marketplace would be anxiously waiting for the next delivery (i.e., new exploration opportunities and the prospect of lower public access costs).

Also, the Shuttle flight software development, Shuttle mission design and crew training processes become limited in scope and more affordable (for the customer reimbursing the Shuttle program) if accounted for using the marginal cost approach.

Additionally, since the deployment mission is relatively simple to conduct, only a small flight crew would be needed. There would be few, if any, mid-deck lockers to build up and install, fewer crew seats - the total focus would be on delivery of lunar packages for the benefit of Americans. Again, some of these will be paying customers as visitors to theme parks, planetariums or science centers, some as investors in a business venture, while others as students or professors in academia anxiously awaiting his or her opportunity to explore and interact with the space environment.

Several forces have led the Shuttle program to manifest unique payload missions only and thus incur the ensuing Orbiter work to accommodate them. First, we no longer see commercial deployments from Space Shuttle Orbiters. Additionally, with the advent of Space Station operations, unique science missions are best suited to be performed there rather than on dedicated Shuttle flights. As a result of this and the recent change in orbit inclination for the ISSA, the Shuttle program now has surplus launch capacity with its Orbiter *Columbia.* This surplus comes not only in the form of an Orbiter - but also as facility space and engineering talent. Further definition of national space launch policy is required, however, to take full advantage of this surplus as an opportunity for American free enterprise. The nation now has a choice to eliminate the "excess" or provide them with a relevant framework to once again serve the American public.

Next: Re-Engineering the Vehicle for Lower Cost and a Higher Flight Rate Capability

The Space Shuttle *Columbia,* with a focused cargo delivery role, would be an ideal vehicle to take full advantage of mature technologies awaiting flight demonstration. Focusing development changes on one vehicle, prudently, over time, avoids production investments best left for advanced transportation projects (for example, the X-33). Using design, development, test and evaluation (DDT&E) resources only to include first unit acquisition would allow optimization of the design (including flight operation, turnaround and cost performance) without incurring any production costs. If the development improvements on *Columbia* prove (through actual flight and turnaround use) to be cost effective, then at that time the launch vehicle organization(s) could pay for their production for use on the other vehicles.

Application of more robust and dependable thermal protection technologies in high damage areas of the vehicle would be an appropriate first choice. Some technologies have already proven their wear and tear maturity on previous flights. One reason for their limited application is the production costs that would be incurred to retrofit the entire Shuttle fleet without an associated demand for fully utilizing their turnaround benefit. Other opportunities include development of maintenance-free wings, i.e., the elimination of corrosion control work, more robust leading edge insulators, simpler and maintenance-free aerosurface hinge-line sealing mechanisms, etc.

Additionally, simplified, more dependable and more operable actuation systems can be demonstrated. Simple candidates that can realize immediate benefit include electrically operated landing gear, brakes, nosewheel steering control, and Orbiter to External Tank umbilical retraction actuators. Developing completely sealed hydraulic systems (i.e., remaining sealed launch after launch) can be enabled through application of high performance electric pumps or through high-powered electric power distribution systems for electro-hydrostatic actuators. This can increase the vehicle's capability to be quickly and affordably prepared for launch and alleviate the need for the overtime and shift work expense involved with operating, servicing and sampling ground hydraulic equipment.

Also needed is the development of rapid and autonomous vehicle power application through the use of advanced, low power avionics. If designed for, this could enable ground vehicle processing operations that are free from complex ground cooling support equipment. This would also result in significantly simplified operations with lower levels of required support. Other avionics advances that would allow faster and simpler turnaround include combining navigation functions into an Integrated Global Positioning Satellite/Inertial Navigation System (GPS/INS).

Still another avenue worth pursuing includes combining the $H_2/0_2$ fuel cell power reactant storage & distribution system (PRSD) with the forward reaction control system. What is envisioned here is development of a forward reaction control module fueled not directly from the ground with toxic/hazardous propellants, but rather utilizing common tank storage for both the fuel cells and $H_2/0_2$ gas-gas reaction jets. This propulsion technology has already been flight demonstrated on the McDonnell Douglas DC-X. Using this approach on *Columbia* would benefit the X-33 program by providing a full scale, orbital flight demonstration of the technology, while at the same time the customers would get the benefit of a more affordable and responsive launcher in the near term.

Many other innovations are expected to arise from the smallest of improvements to more ambitious system technology innovations. Contractor operators and the government flight test engineers at the launch site would have an incentive to work directly with design engineers and researchers across the country - not only within the Shuttle program, but with other programs, such as X-33, commercial aircraft design teams and airline operators. With this type of teamwork, and a structured framework to organize for improvement, there should bean ability to double the current flight rate capability while lowering the per flight costs of operating the *Columbia.*

Summary

An engineering framework has been examined for improving the flight rate capability and per flight cost of operating one Space Shuttle Orbiter. How this maybe achieved has been outlined in terms of system and component upgrades that can be demonstrated in orbital flight and at full scale. *What* role this Orbiter would fulfill in demonstrating a higher flight rate has been identified to be a cargo deployment only role.

Private demand for lunar enterprises that continually deliver revenue-generating devices to the Moon for public benefit on Earth is forwarded as a realistic, near-term justification for pursuing this approach. The approach not only promotes maturing space transportation technologies, but also provides the chance for government developmental resources (such as Shuttle Columbia) to cooperatively serve America's expanding free enterprise system.

Conclusion

American dreams of space exploration beyond Earth orbit are all around us. From LunaCorp's and others' visions of starting ground-based space theme parks to SpaceCamps, science centers, I-Max movies, and planetariums. Consider the success of the many space-related television programs, theater films and videotapes.

In NASA's latest Strategic Plan one can read that *"NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth."* It further states that *"in fulfilling its mission NASA contributes to America's goals in . . . economic growth . . . educational excellence . . . and peaceful exploration and discovery."*

Cooperatively using the Space Shuttle *Columbia* with private firms to initiate lunar enterprises, while simultaneously developing space transportation technologies, can serve to unite NASA's strategic enterprises in space sciences, space access and technology and in the human exploration and development of space. If we are successful, those of us who have the privilege of working with NASA and its contractor work force will have served the public by bringing the Moon to the marketplace and thereby making their public investments in space research significantly more relevant. With global competitors having stated that they are heading to the Moon and beyond, with or without the United States, NASA can no longer afford to postpone making its strategic goals truly relevant to the American dream of exploring and leading free enterprise into space.

References

[1] *Commercial Space Transportation Study - Final Report,* CSTS Alliance, May1994; pp. 264,267
[2] Aviation Week& Space Technology article, "Shuttles Shuffled," January 29, 1996, p. 45.
[3] *NASA Pocket Statistics,* NASA History Office; Washington, DC, January 1993.